Recent Developments for an Orbiting Sample (OS) Container for Potential Mars Sample Return

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Scott Perino
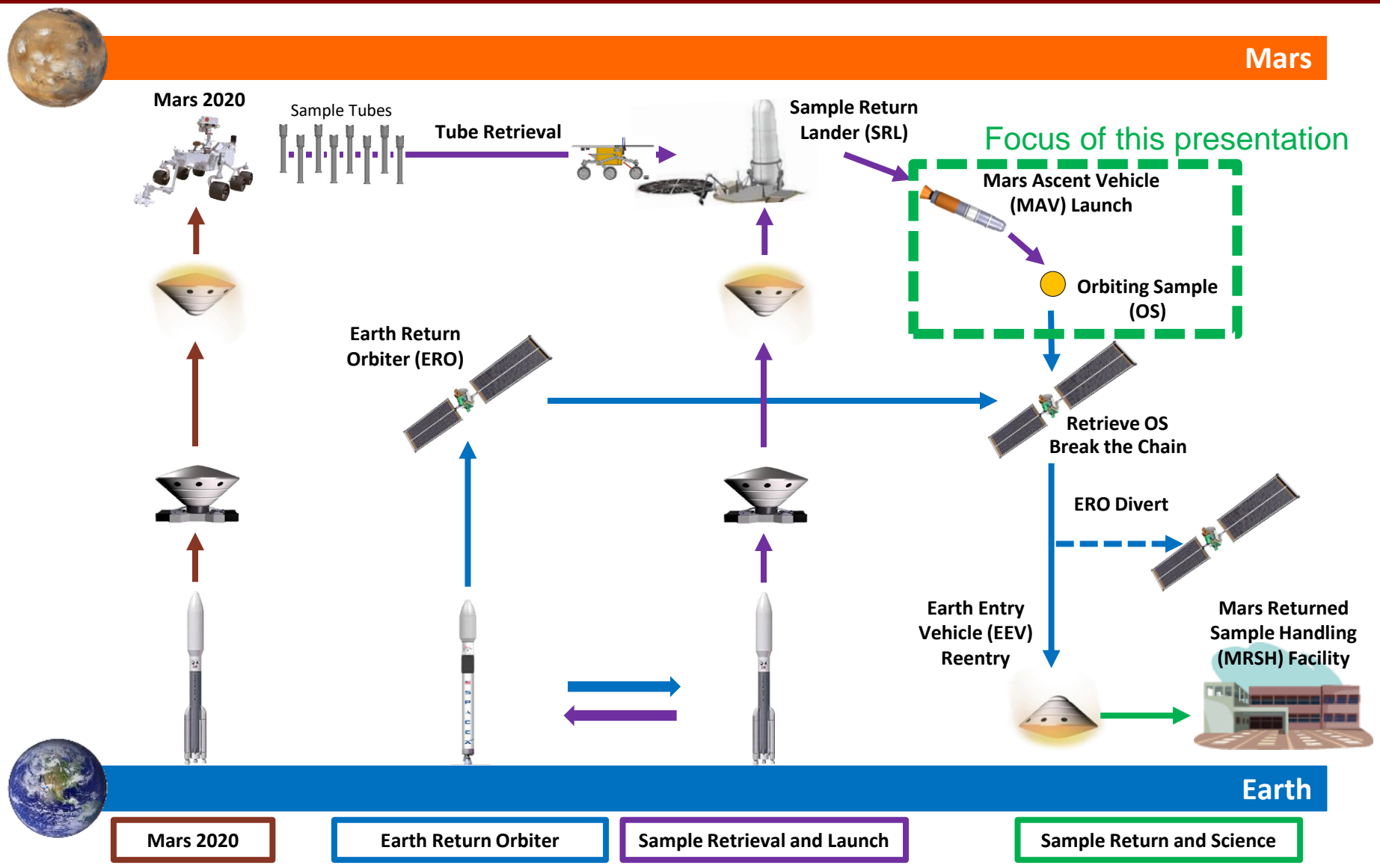
Tom Komarek

Jet Propulsion Laboratory,

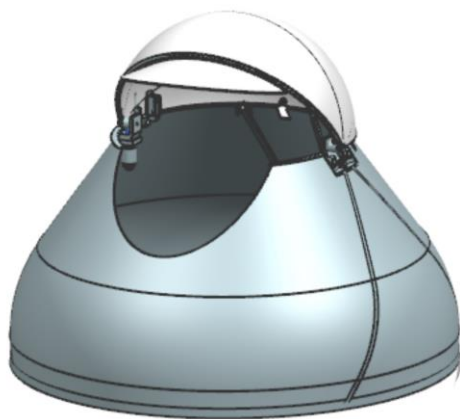California Institute of Technology

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International Planetary Probe Workshop 2018

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Potential Mars Sample Return Overview

Mars

Mars 2020

Sample Tubes

Tube Retrieval

Sample Return Lander (SRL)

Focus of this presentation

Mars Ascent Vehicle (MAV) Launch

Orbiting Sample (OS)

Earth Return Orbiter (ERO)

Retrieve OS Break the Chain

ERO Divert

Earth Entry Vehicle (EEV) Reentry

Mars Returned Sample Handling (MRSH) Facility

Earth

| Mars 2020 | Earth Return Orbiter | Sample Retrieval and Launch | Sample Return and Science |

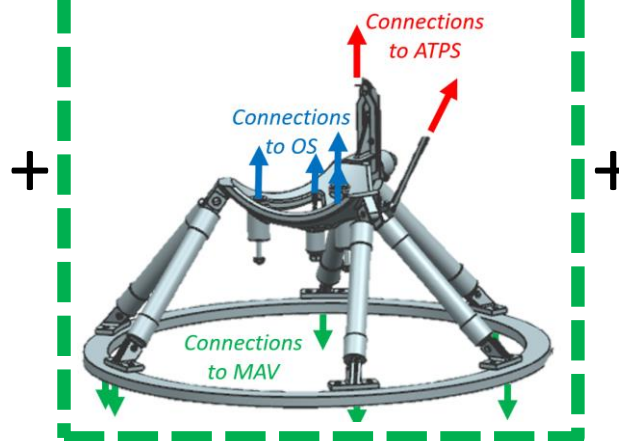Pre-Decisional: For Planning and Discussion Purposes Only

MAV OS Payload System (MOPS)

Aero-Thermal Structure (ATS)
Protects the OS from aerodynamic & thermal loads, also allows OS canister insertion & ejection

OS Mechanical Support Structure (OMSS)
Supports OS during MAV launch and ejects OS into Mars Orbit

Orbiting Sample (OS)
Holds & protects tubes, Surface plating & beacon ensure OS can be recovered in Mars Orbit
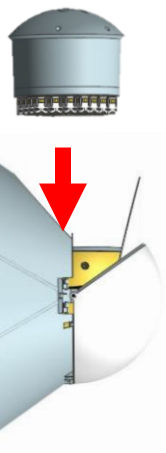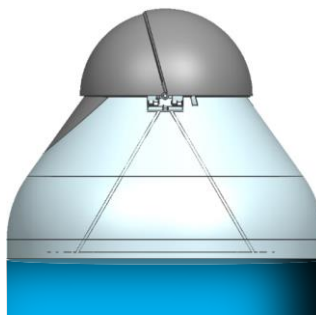
MOPS = + +

Connections to ATPS
Connections to OS
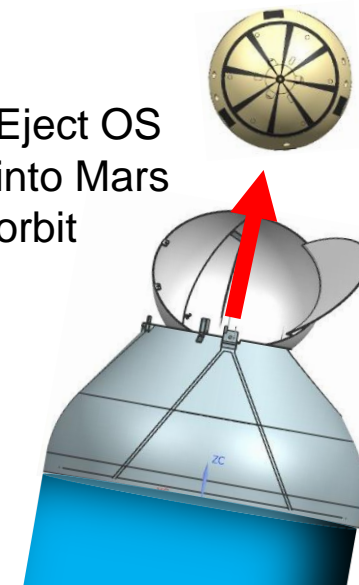Connections to MAV

Structures

ConOps

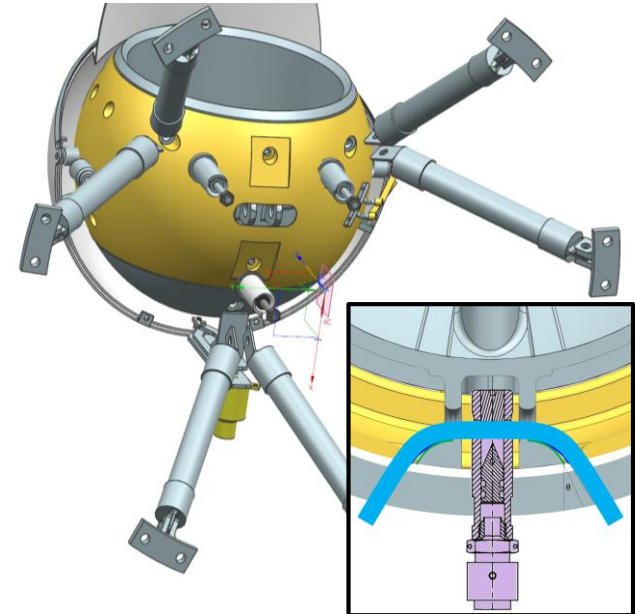1. Insert & secure OS-canister

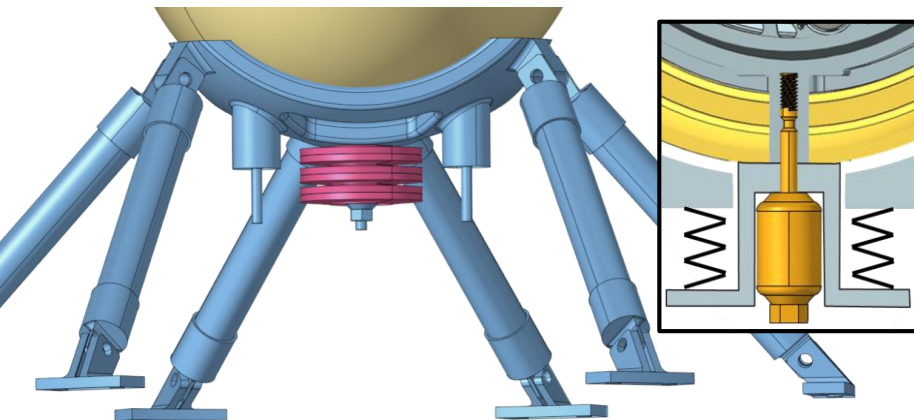2. Prepare and launch

3. Eject OS into Mars orbit

OS-to-OMSS Interface

- Requirements for OS-to-OMSS connection
    - Strong enough to withstand heavy random vibe loads during Mars Ascent; random vibe analysis indicates OS pulloff load to be around 15 kN
    - Allow for controlled, reliable OS release
    - Require no positive features on the OS
- Most concepts require dedicated interface features on the OS itself; therefore, the OMSS design directly influences the OS design
- For simplicity, desire to have single separation mechanism
    - Need axial and lateral compliance to avoid over-constraining
    - Two suitable approaches identified; several concepts explored
        1. **Through-cable with cable cutter**
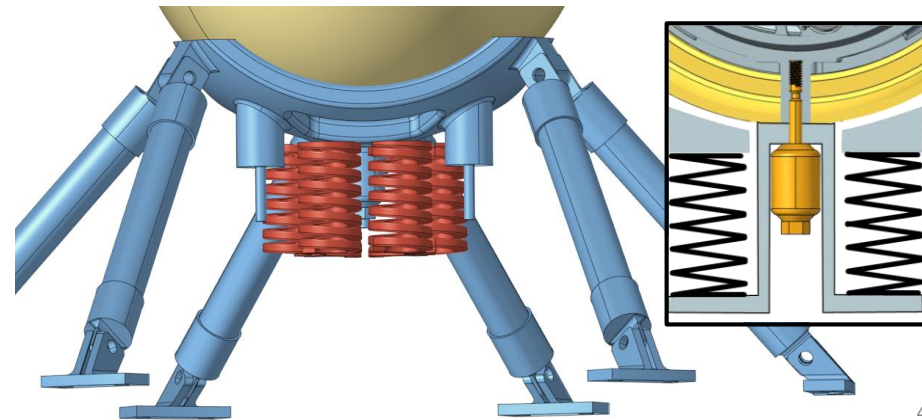   2. **Spring-mounted frangibolt**

Through-Cable Restraint with Cable Cutter

**Frangibolt Mounted on Belleville Springs**

Frangibolt Mounted on Array of Compression Springs

Pre-Decisional: For Planning and Discussion Purposes Only

OMSS Overview

NASA Jet Propulsion Laboratory, California Institute of Technology

- **Latest design uses a single frangibolt suspended on Belleville washers**
  - Components sized to carry 15 kN peak load safely
- OS interfaces with the MOPS saddle at four locations
  - Secure interface with the Frangibolt
  - Loads reacted at 3 cup-cones
- Cups sit on flat part of OMSS cone
- Lateral loads may induce limited slip, which then gets reacted by saddle cones

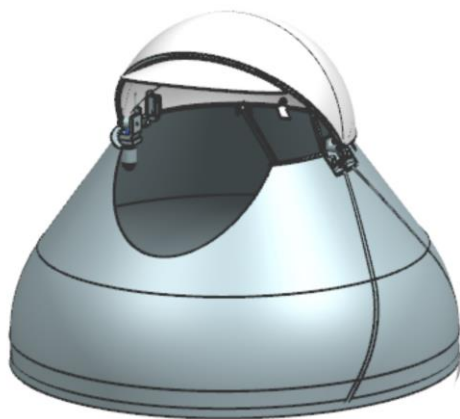Pre-Decisional: For Planning and Discussion Purposes Only
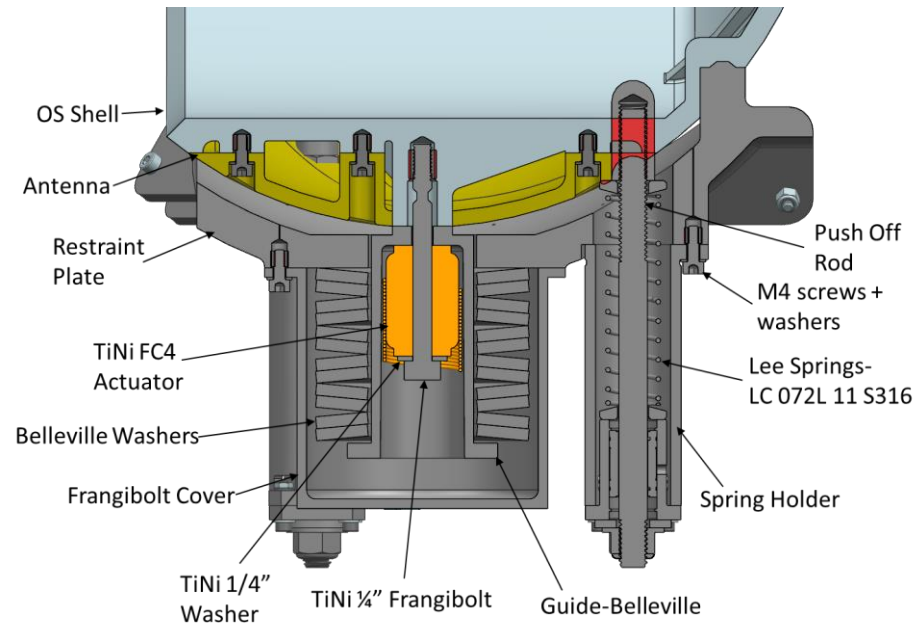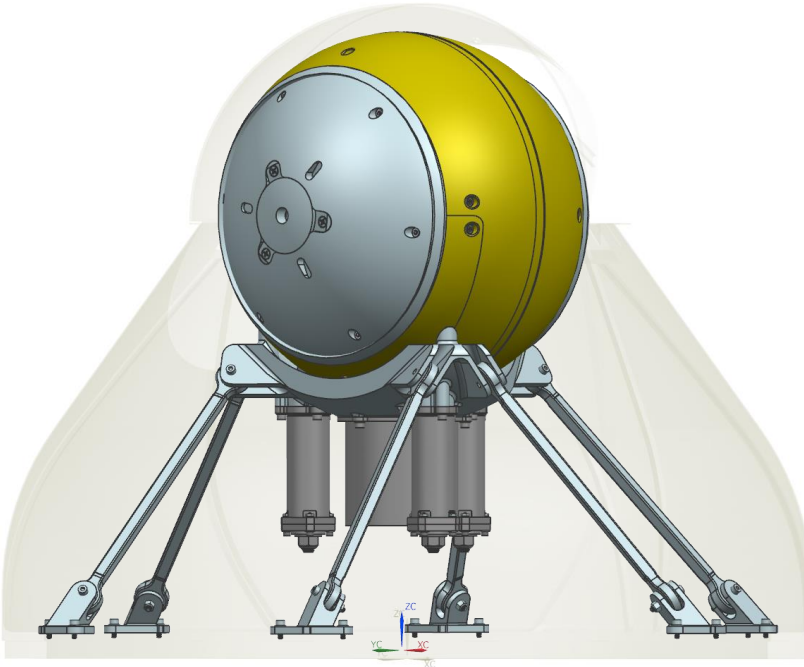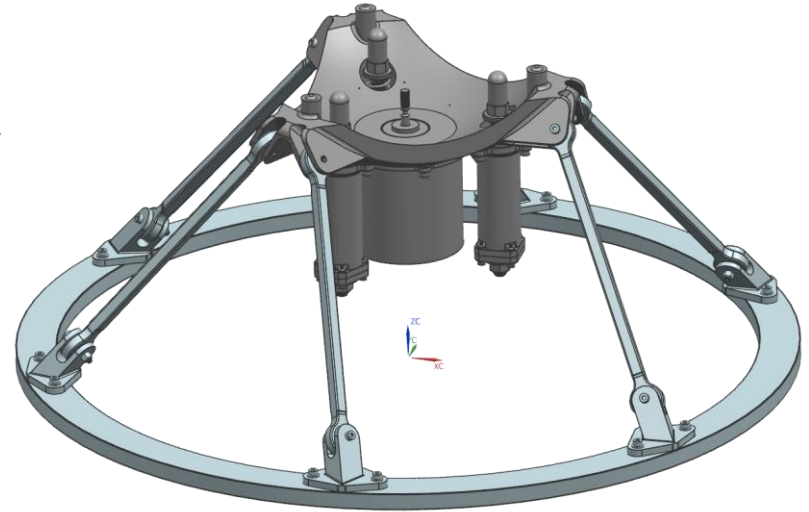
MOPS Structures & ConOps

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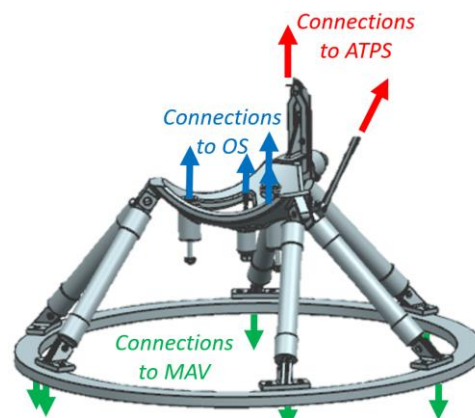
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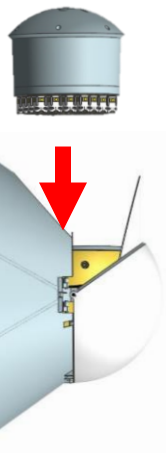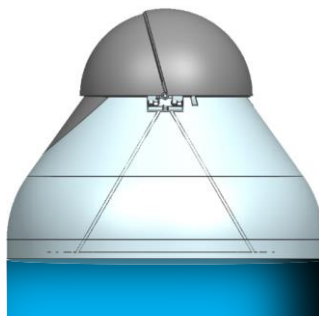
MOPS =

+

Connections to ATPS

Connections to OS

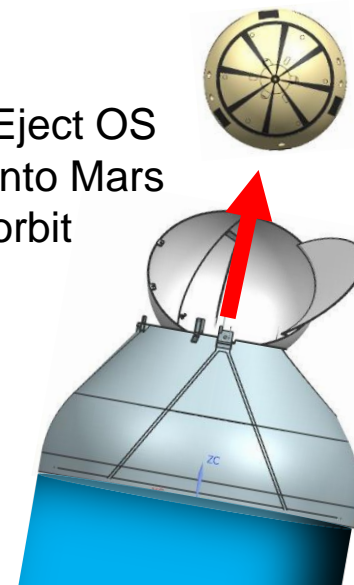Connections to MAV

+

Structures

ConOps

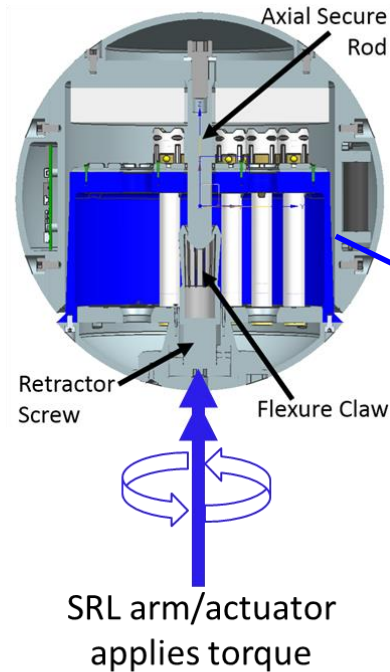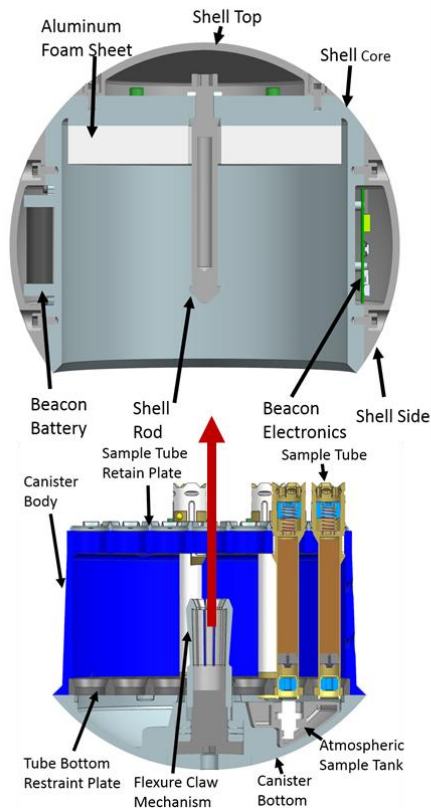1. Insert & secure OS-canister

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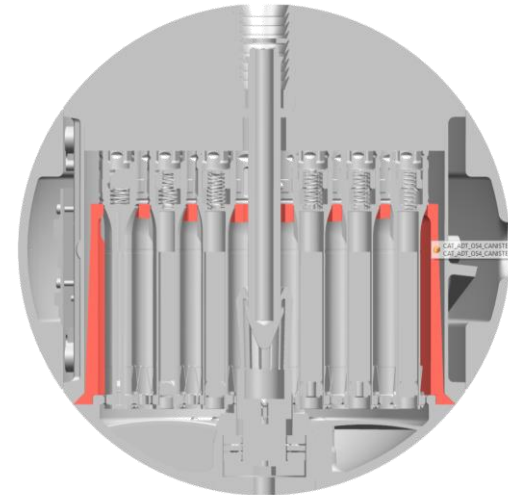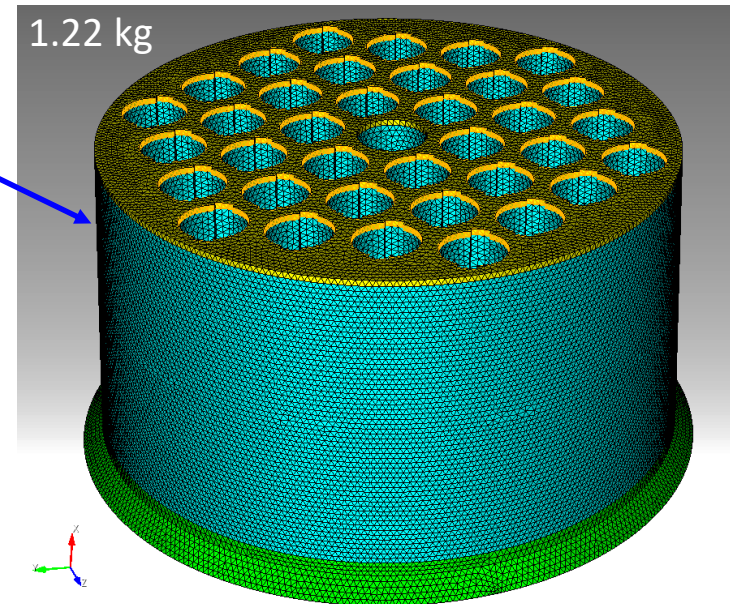
OS Topology Optimization

- **Goal: Minimize Orbiting Sample (OS) mass/weight**
  - 1 kg mass savings for the OS could save 5 kg for the MAV and 20 kg for the Lander
- First target for topology optimization (top-opt): Canister body
- Utilizing Sandia National Lab code Plato for top-opt
- OS assembly is the logical first load case to examine
 - Tubes clamped between canister and Al foam during assy

Aluminum Foam Sheet — Shell Top — Shell Core

Beacon Battery — Shell Rod — Beacon Electronics — Shell Side

Canister Body — Sample Tube Retain Plate — Sample Tube — Atmospheric Sample Tank

Tube Bottom Restraint Plate — Flexure Claw Mechanism — Canister Bottom

Axial Secure Rod

Retractor Screw — Flexure Claw
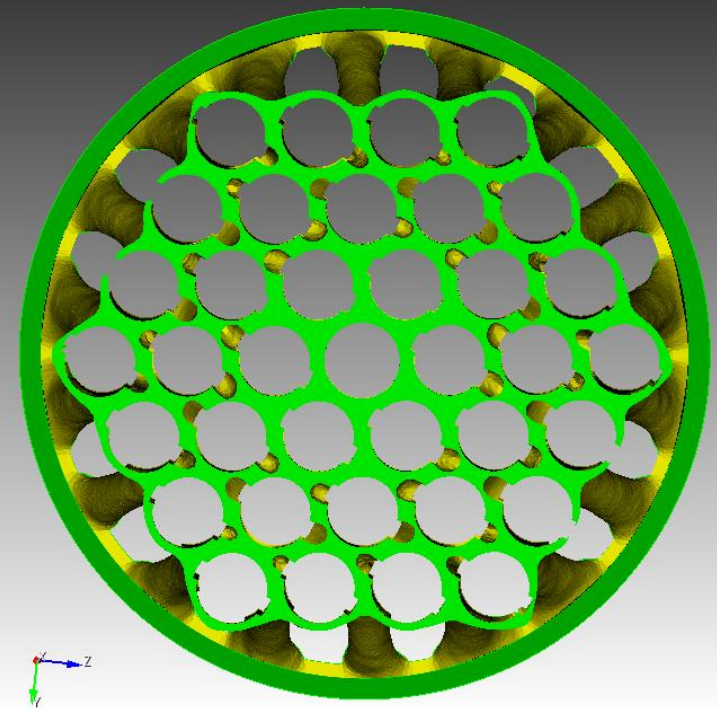
SRL arm/actuator applies torque

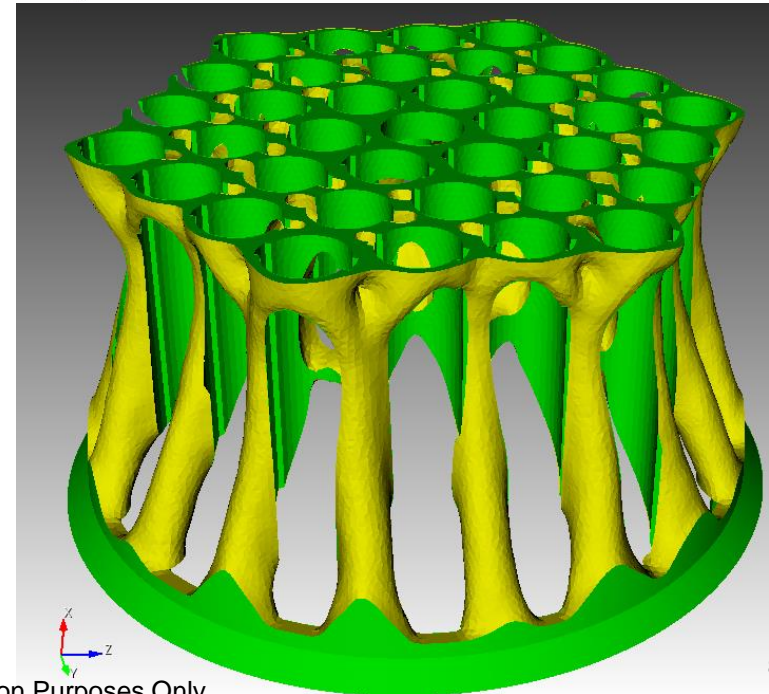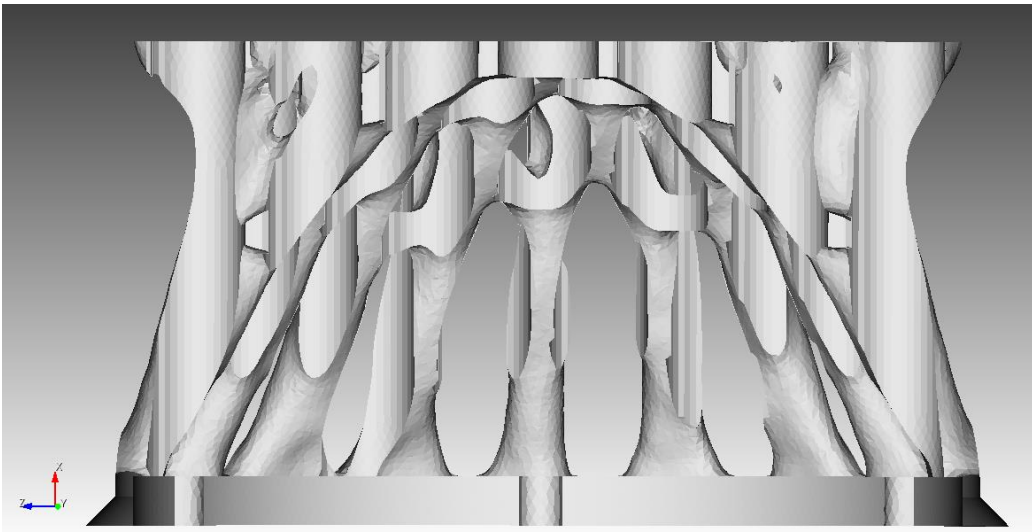1.22 kg

7

Initial Top-Opt Results

- Ran code in "compliance minimum" mode
- Volume fraction of initial total space: 0.25
- Optimized mass: 1.13 kg
- Tree-like structures "growing" from perimeter
- Dome-like interior profile

2.5 N

147.5 N

147.5 N

2.5 N
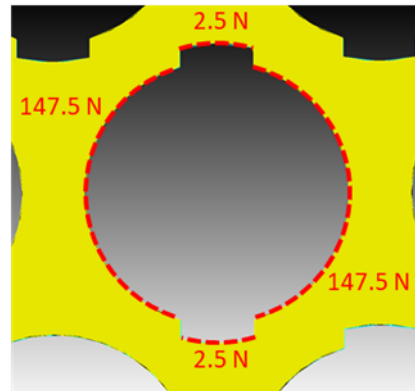
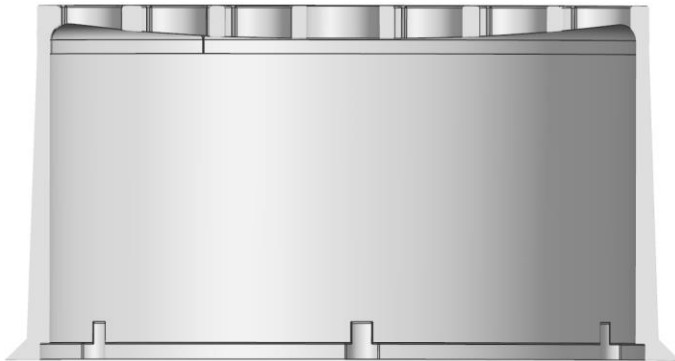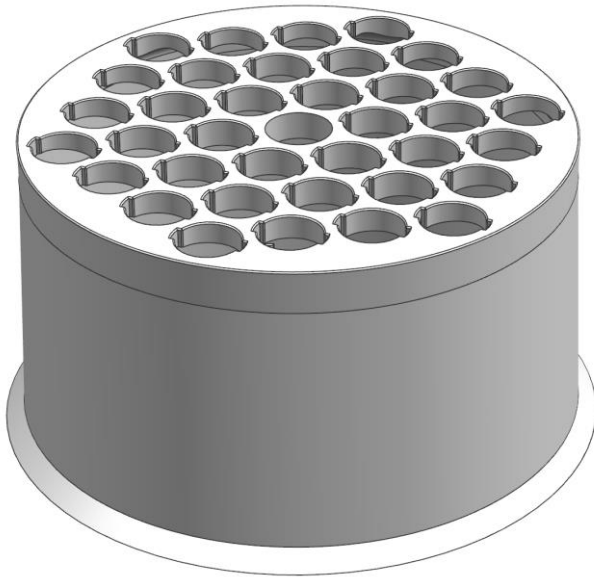Load distribution around socket
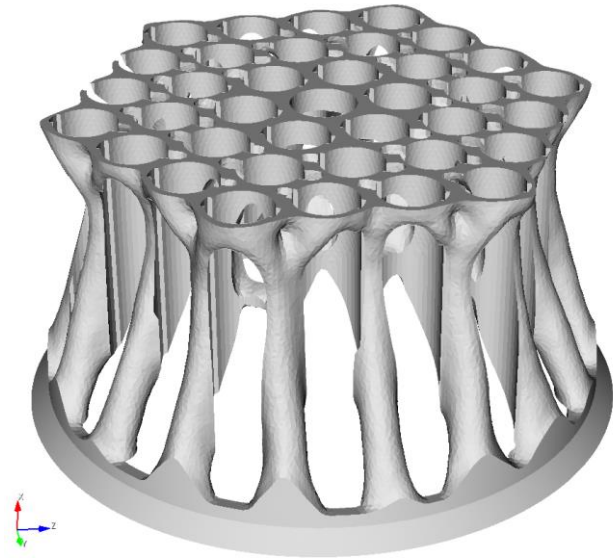Total load per socket = 300 N

Section cut view

Initial Top-Opt Results

Current

Optimized

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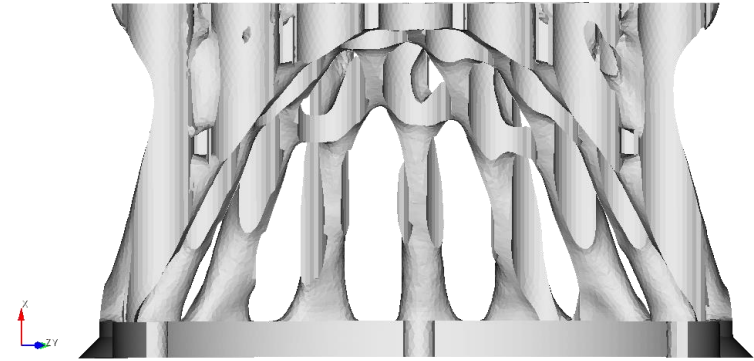
Initial Top-Opt Results

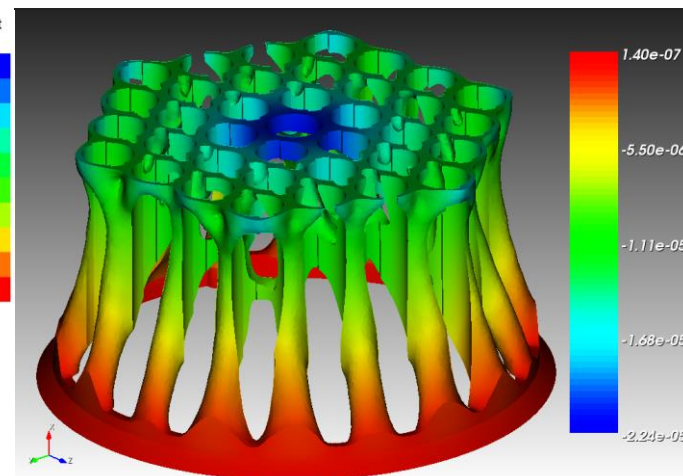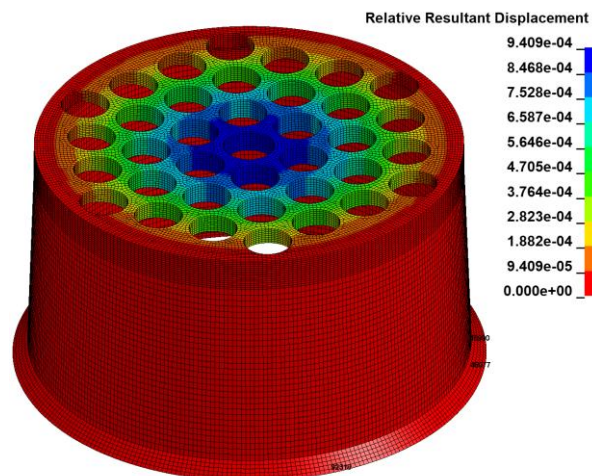| Metric	Limit	FS	Reference	Optimized
Peak VM Stress	200 MPa	1.25	202 MPa (MS = -0.21)	26 MPa (MS = +5.2)
Peak Displacement	1.5e-4 m	1.0	9.4e-4 m (MS = -0.84)	2.2e-5 m (MS = +5.8)
Weight	-	-	1.22 kg	1.13 kg

Current   Optimized

VM stress

Vertical displacement

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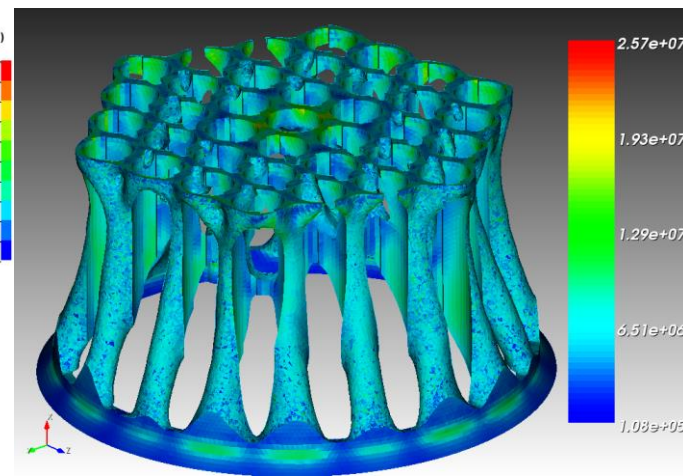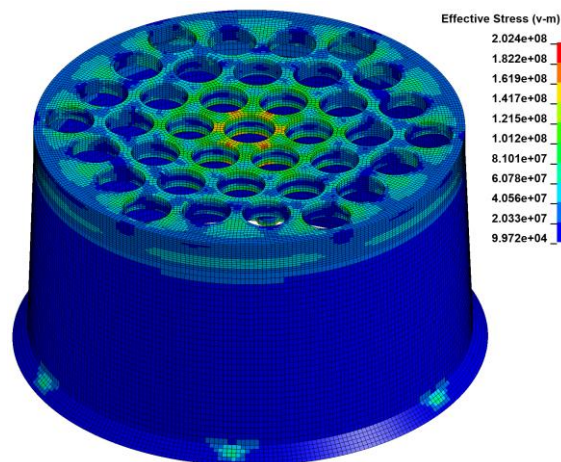
Summary and Next Steps

- OS attachment to the MAV is fully conceived and can withstand the strong vibe loads experienced during MAV Ascent

- Initial OS topology optimization results are promising and provide insight into what a more efficient OS canister body design may look like

- Given the large positive margins in the OS canister body, further mass reduction may be possible

- Next, impact analysis using an explicit FEA code will be incorporated to assess the geometry resulting from topology optimization
  - Limiting load case for the OS is likely impact; needs to be assessed
  - LS-DYNA models exist, and modeling using the SNL code Sierra is in development
  - Explicit FEA cannot be incorporate directly into the optimization process; will mesh geometry resulting from optimization and incorporate into existing analyses

THANK YOU FOR LISTENING!

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BACKUP

OS Overview

Mass estimate: [9.50] kg

Ø270 mm

OS Shell Assembly

RSTA

OS Canister Assembly

Crushable
Aluminum Foam

Aluminum
Shell Core

Torlon Antenna
Shell

Beacon and
Battery Volume

Atmospheric
Sampling Volume

36X RSTA